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DELAY ACTIVATOR, SILICONE

SUMMARY LETTER REPORT

ON

WORK ORDER NO. IX,  
TASK ORDER NO. CC

July 26, 1959

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July 26, 1959

Dear Sir:

This letter report describes the work done under Work Order No. IX, Task Order No. CC, during the period March 27 through July 26, 1959.

Background Information

During the past several years, a search by many organizations for a cheap, reliable, and reasonably accurate time-delay mechanism led to the consideration of silicone fluid as a timing medium. Under Task Order No. J, basic design criteria were established for an experimental time-delay unit using silicone fluid. The effort under that Task Order was directed toward the development of an experimental unit for use in providing time-delay periods ranging from 15 minutes to 2 months, at temperatures varying from -20 to +120 F; the desired accuracy was such that the flow of silicone fluid could not vary more than  $\pm 10$  per cent over this range of temperatures. In the research performed under Task Order No. J, it was found necessary to incorporate in the experimental unit a device designed to provide temperature compensation, so that changes in the viscosity of the fluid that were brought about by temperature variations would not cause the flow to vary beyond the specified limits.

Subsequently, you described to us a need for another time-delay unit, namely,

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inexpensive, reliable, and relatively small. There appeared to be a good possibility that some of the data obtained under Task Order No. J could be used advantageously in connection with a development study of a device of this kind. The deep water in which such a device would be operating under service conditions would not suffer major fluctuations in temperature. In view of this and on the basis of preliminary calculations, it appeared that a study directed toward the development of a device which would use silicone fluid and would be suitable for the application of interest would not have to include consideration of means for temperature compensation.

On March 27, 1959, Work Order No. IX, Task Order No. CC, was undertaken to design, fabricate, and conduct a preliminary evaluation of a device to fulfill the above-outlined requirements. The details of the effort performed are described in the following.

#### Summary

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#### Specifications for the Time-Delay Device of Interest

On the basis of discussions with you, a series of specifications was formulated. Thus, under service conditions in sea water at a temperature

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within either of two ranges, namely, 30 to 50 F, and 50 to 70 F, it would be desirable for the device of interest to:

- (1) Have neutral buoyancy.
- (2) Remain watertight for at least 1-1/2 years at a maximum depth of 200 feet.



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- (4) Be self-contained, i.e., emit no silicone fluid to the ambient water.
- (5) Have outer dimensions of up to about 1-1/2 inches in diameter or maximum thickness, and a length as short as possible.
- (6) Be capable of attachment to a receptacle, the dimensions of which would be provided.

#### Design of a Proposed Time-Delay Device

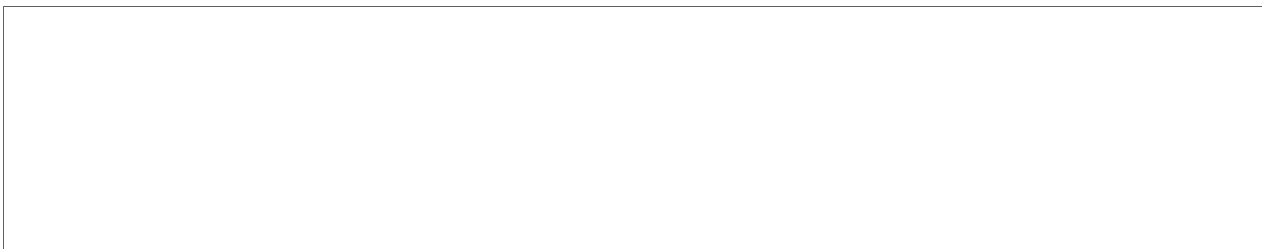
The results obtained on two previous programs were used as a basis for the design of a proposed time-delay device. Under one of these programs, Task Order No. G, the effort was directed toward the development of experimental containers which would remain watertight during immersion in sea water for periods up to 5 years. In this research, it has been demonstrated that certain aluminum alloys can be immersed in sea water for more than 1-1/2 years without being damaged seriously; and rubber O-rings have been used successfully to seal the closures. On the basis of these results, it was decided that the outer case of the time-delay device of interest should be made of wrought 5052 or cast 356 aluminum alloy and sealed by an O-ring.

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From the data obtained under Task Order No. J, we originally calculated that a tube about 10 inches long with an inside diameter of about 0.007 inch would serve to control satisfactorily the flow of about 1-1/2 cubic inches of Viscasil 500,000 for the time-delay period of interest. Subsequent work showed that this Viscasil would not reliably flow through a 0.007-inch-diameter tube, while it would flow satisfactorily through a 0.010-inch-diameter tube. Further calculations showed that a volume of about 2 cubic inches of Viscasil 500,000 should be adequate when used with the larger sized tubing. Further information from Task Order No. J allowed us to determine that the force needed to extrude this fluid through the tube could be supplied by a helical, steel compression spring, and that the force could be transmitted to the fluid through a rubber Bellofram piston seal.

Figure 1 is a layout which was prepared for a proposed time-delay device. The silicone fluid was to be contained in a chamber formed by the end cap and the Bellofram piston seal. Pressure would be applied to the fluid by means of a spring-loaded piston, and the fluid would be forced to flow through the regulating tube, through the opened spool valve, and into the volume partially occupied by the spring.

Flow in the proposed unit would be initiated by means of a simple spool valve located at one end of the regulating tube. In Figure 1 the valve is shown closed. To permit flow, the spool would be pulled out; the valve would then be open, and the fluid could flow through the valve and into



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One internal safety interlock was provided to prevent the use of a timer of this type that might have lost fluid and thus might be subject to premature actuation. This interlock was achieved by permitting the inner end of the spool to extend into a hole in the piston; this hole was shaped so as to prevent the spool from being pulled out if considerable leakage had occurred (and the piston had moved a corresponding distance), and also to restrain the piston from movement after a small amount of leaking.

It was visualized that in a production model of such a timer, two more external pin-type safeties would be desirable. One of these could pass through the spool to prevent accidental actuation, and the other could be located behind the firing pin to prevent premature firing.

#### Design of a Laboratory Model

To permit the testing of the principles shown in Figure 1, a laboratory model of the time-delay device was designed and this embodied several differences. Figure 2 is a drawing of the laboratory model. It will be noted that for the laboratory model, the end cap was made thicker to permit the addition of a refilling fitting, the firing-pin mechanism was eliminated, a rod was added to permit the measurement of the piston travel from outside the device, and the flange portion of the rubber Bellofram piston seal was used as a flat-gasket type of seal between the end cap and the housing.

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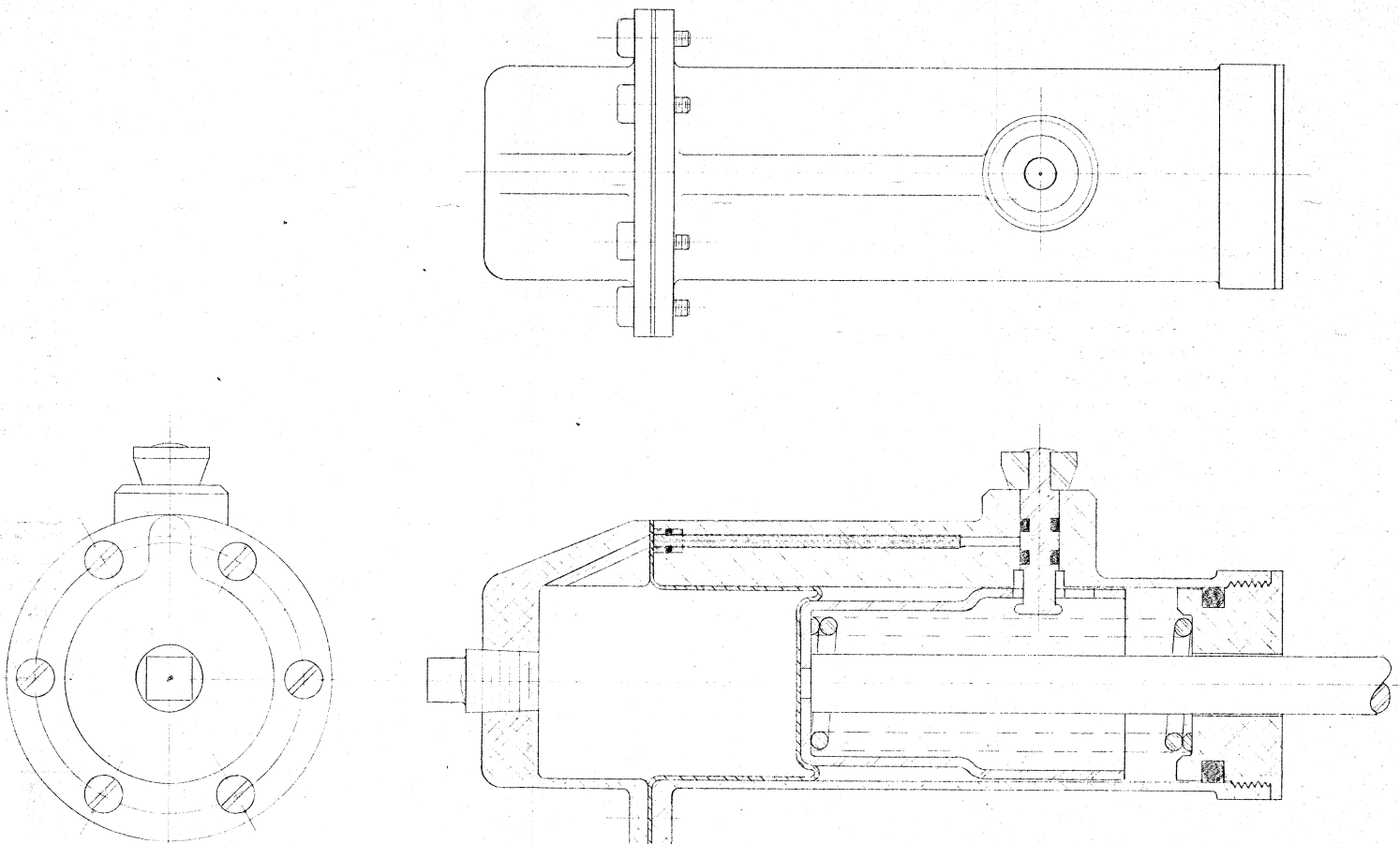


FIGURE 2. DESIGN OF THE LABORATORY MODEL OF THE TIME-DELAY DEVICE

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The regulating tube to be used was stainless steel seamless capillary tubing, 0.075 inch in OD, 0.010 inch in ID, and 2 inches in length.

#### Evaluation of the Laboratory Model

Upon completion of the parts of the laboratory model, the unit was partially assembled and then filled with Viscasil 500,000 fluid using the following procedure. As shown in Figure 2, the Bellofram seal formed one part of the fluid storage chamber, while the flanged end cap provided the other part. Both parts of the chamber were filled to slightly above full and allowed to sit for 24 hours to allow any trapped air to escape; the end cap was then bolted to the housing. An exterior valve, inserted in the flanged end cap for experimental purposes (not shown in Figure 2), was opened to allow any other trapped air to escape. The piston was permitted to move slightly, and a small amount of the Viscasil was allowed to escape through the open valve. The valve was then closed and the device was set up for the operating test at ambient (room) temperature. A direct-reading dial indicator was placed against the piston rod and set to a zero reading. Also attached to the test stand was an accurate thermometer for indicating the ambient temperature. The unit was allowed to sit for an additional 24 hours and was then actuated.

Daily readings of the movement of the piston were taken. As the test data began to accumulate, it became apparent that the device was operating at a speed at least 50 per cent greater than that originally calculated. The first thought was that leakage of the Viscasil from the device might be causing the high readings; consequently, "C" clamps were applied to provide additional clamping at the flanges. To obviate the possibility of leaks in

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the filling piping, the exterior valve was removed and a pipe plug was inserted in the flanged end cap.

The tests were then continued, but the data obtained indicated no reduction in the rate of piston travel. It appeared that only one area remained as a source of leakage - the seal at the regulating tube and the regulating tube itself; the regulating tube was sealed in position by means of one small O-ring.

In an effort to determine whether there was leakage at the regulating-tube O-ring, the test unit was disassembled and cleaned, and the O-ring and regulating tube were removed. Inspection of the regulating tube revealed small lathe collet or chuck marks (or grooves) on the outside surface of the tube; it appeared that these grooves might have permitted leakage of the fluid past the tube and the O-ring. Subsequently, the unit was re-assembled using a new regulating tube and three O-rings stacked together, with liquid-gasket-seal material applied to the stacked O-rings, to the outside of the tube, and to the inside of the hole which housed the tube and the O-rings.

The measurement of the diameter of the new regulating tube was accomplished as follows. The tube was cut to the proper length with great care exercised by the machinist; every effort was made to insure that the hole was neither burred nor tapered enough to influence the subsequent measurement of the tube-end diameters. A precision microscope was then used to measure each tube-end diameter, first, across the tube in one direction and second, after the tube was rotated axially through 90 degrees. These two readings for each end were averaged, and then the two end values were averaged, to obtain a value for the diameter of the tube orifice.

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After re-assembly of the unit, the test at room temperature was resumed. The data obtained indicated that the flow was only about 16 per cent higher than the calculated value. Thus, it appeared that the new-regulating-tube inner diameter was closer to the appropriate size than had been the original-regulating-tube inner diameter, and/or the original single O-ring seal had not been satisfactory.

It was realized that the tube inner diameter could vary somewhat throughout any given length of tube, and also that the flow rate would vary as the fourth power of the inner diameter\*. Consequently, it appeared that calibration of the regulating tube was necessary.

With this thought in mind, the regulating tube was removed from the laboratory model and attached to a source of constant air pressure. The silicone fluid was allowed to extrude into a closed container which was accurately weighed every 24 hours, to determine the actual flow without the effects of unknown variables, such as leakage, being a factor in the final results.

The results of this final test demonstrated the consistency with which the silicone fluid would extrude through an orifice tube; the flow was only 2.6 per cent higher than the flow through the tube when assembled in the laboratory model of the timer. All of the tests were run at room temperature, which fluctuated daily. It is considered likely that, under more constant temperature conditions, the difference between the flow obtained in the tube calibration tests and the actual flow through the tube incorporated in the timer can be decreased to less than 2.6 per cent.

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\*This was discussed in the "Second Summary Report on Task Order No. J" dated February 28, 1959.

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Future Work

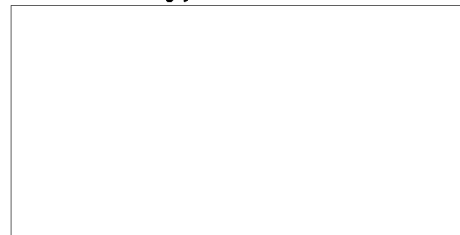
On the basis of the information obtained from this research, it appeared that finalization of a time-delay device could be forthcoming with a small amount of additional work. There was, however, the necessity for:

- (1) determining the best method of calibrating the regulating tube,
- (2) investigating the use of a Bellofram piston seal provided with an O-ring seal, to minimize the chance of fluid leakage at the piston seal, and
- (3) streamlining the exterior of the device to obtain improved underwater-flow characteristics.

In accordance with your subsequent request, a proposed program of research dated August 13, 1959, was submitted that was directed toward accomplishing the above-described efforts, and preparing and evaluating four units of this type so that the problems which might be encountered in production could be explored. (This program was subsequently undertaken under Task Order No. LL.)

We would appreciate any comments which you or your associates might care to make with regard to our efforts under this Work Order.

Sincerely,



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In Triplicate

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